B. *The Higley method* used in most modern cephalostats uses one X-ray source and film holder with a cephalostat capable of being rotated. The patient is repositioned in the course of the various projections.

2. *The lateral projection* (Figs 9.2 and 9.3)
   A. *The midsagittal plane* of the subject's head is conventionally placed at 60 inches (152.4 cm) from the target of the X-ray tube with the left side (European convention is the right side) of the subject towards the film. The central beam of the X-ray coincides with the transmeatal axis, i.e. with the ear rods of the cephalostat. Under most circumstances, the distance from the midsagittal plane to the film is held constant, usually at 7 inches (18 cm). This distance can vary from machine to machine, but should remain the same for each patient every time his/her radiograph is taken. In the Brodbent-Bolton cephalometer, this distance is varied according to the subject. The patient's head is placed with the Frankfort plane parallel to the floor and the subjects teeth together in their usual occlusal position and the lips are left loose.
   B. *The posteroanterior projection* (Fig. 9.4) The head is rotated by 90 degrees so that the central ray perpendicularly bisects the transmeatal axis. It is crucial that the Frankfort plane be accurately horizontal, because when the head is tilted, all vertical displacements measured are altered.
   C. *Oblique projections* The right and left oblique cephalograms are taken at 45° to the lateral projection, the central ray entering behind one ramus to obviate superimposition of the halves of the mandible. The Frankfort plane must stay horizontal; any tipping will alter measurements. The oblique cephalogram is particularly useful for patients in the mixed dentition. But has been rarely prescribed by the clinicians.

TRACING TECHNIQUE

Tracing should be systematic. One should begin with a general inspection of the cephalogram and then locate and identify standard landmarks. This is followed by tracing the anatomic structures in a logical sequence, and finally constructing derived landmarks and lines.

Fig. 9.2: Lateral cephalogram

Fig. 9.3: Lateral cephalogram

Fig. 9.4: P-A cephalogram

STEPWISE TRACING TECHNIQUE

Step 1

Draw at least two plus shaped crosses on the top right and left corners of the radiograph. These are drawn away from any landmarks and are used to orient the tracing over the radiograph.

Step 2

Trace the soft tissue profile, external cranium, and the cervical vertebrae.

Step 3

These are followed by the tracing of the cranial base, internal border of cranium, frontal sinus, and ear rods (Moorrees recommends abandoning porion and instead using the superior border of the head of condyle to define FH).

Step 4

Maxilla and related structures including the *key ridges* (which represent the zygomatic processes of the maxillary bone) and pterygomaxillary fissures are then traced. The nasal floor is also traced along with the anterior and posterior nasal spines. The first molar and the most anteriorly placed maxillary incisor (including its root) are also traced.

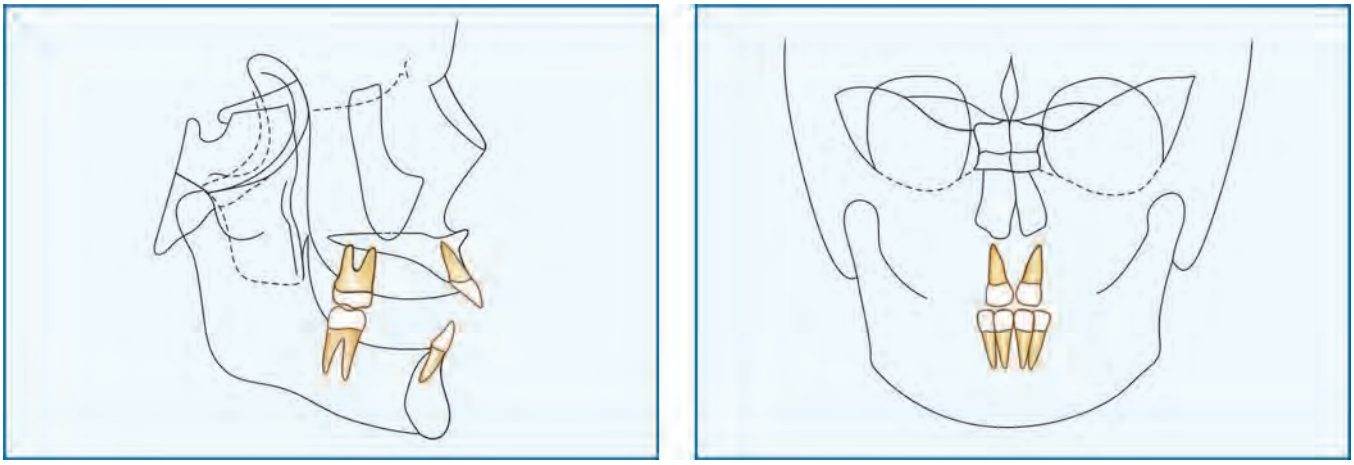
Step 5

Finally the mandible, including the symphysis, the lower border of the mandible, the condyles and the coronoid processes is traced. The first molars and the most anteriorly placed incisor tooth including its root are to be traced. The mandibular canal may be traced and is at times used for superpositioning serial radiographs.

ANATOMIC STRUCTURES IN THE CEPHALOGRAM

Major bony structures seen in the tracing are as follows:

a. *Sphenoid bone,* Figures 9.5A and B show in heavy outline those structures of the sphenoid bone seen most readily in the lateral and posteroanterior cephalograms respectively.
b. *Zygomatic bone,* Figures 9.6A and B depicts the structure of the zygomatic bones ordinarily visualized in the lateral and posteroanterior cephalograms respectively.
c. *Maxilla,* Figures 9.7A and B show the maxillary structures as visualized in the lateral and posteroanterior cephalograms.
d. *Mandible,* Figures 9.8A and B illustrate the mandibular structures seen in the lateral and posteroanterior cephalograms.



Figs 9.5A and B: The sphenoid bone

POINTS AND LANDMARKS—DEFINITION AND REQUISITES

A landmark is a point serving as a guide for measurement. An ideal landmark is located reliably on the skull and behaves consistently during growth. It should not be assumed that all landmarks are equally reliable and valid.

The reliability (reproducibility, dependability) of a landmark is affected by

- The quality of the cephalogram (Figs 9.2 and 9.3)
- The experience of the tracer, and
- Confusion with other anatomic shadows.

The validity (correctness or use as proof) of the landmark is determined largely by the way the landmark is used.

Cephalometric landmarks and points should have the following attributes (according to the Research Workshop on Cephalometrics Organized by The American Association of Orthodontics in Washington DC in 1960):

1. Landmarks should be easily seen on the radiograph, they should be uniform in outline, and should be easily reproducible.
2. Lines and planes should have significant relationship to the vectors of growth of specific areas of the skull.
3. Landmark should permit valid quantitative and qualitative measurements of lines and angles projected from them.
4. Measurements should be amenable to statistical analyses.
5. Cephalometric analysis preferably should not require extensive specialized training on the part of clinical orthodontist.

POINTS AND LANDMARKS—CLASSIFIED

Cephalometric points and landmarks are of the following kinds:

1. Anatomic landmarks or true anatomic points.
2. Implants
3. Derived landmarks. These can be of three types:
   a. External points
   b. Intersections of edges of regression, and
   c. Intersections of constructed lines

TRUE ANATOMIC POINTS

Anatomic "points" are really small regions, which might be located on the solid skull even better than in the cephalogram. Each point has its own scale and its own uncertainty in one or two dimensions. Examples include the anterior nasal spine (ANS). Infradentale (ID), cusp tips or incisal edges (Is), and Nasion (Na).

IMPLANTS

Implants are artificially inserted radiopaque markers, usually made of an inert metal. They are "private points" and their position can vary from subject to subject, making cross-sectional studies very difficult. They may be located more precisely than traditional points and provide precise super positioning, and are ideal for longitudinal studies on the same subject.

DERIVED POINTS

As the name suggests the derived points are derived to or created for the purpose of comparison or calculations of the cephalograms. These are of the following three types.

External Points

External points are points characterized by their properties relative to the entire outline:

a. These points are extremes of curvature, e.g. incision superius (Is)
b. Points whose coordinates are largest or smallest of all points on a specific outline, (e.g. "A point", "B Point". Gnathion (Gn), or Condylion (Co)
   These points have less precision of location than true anatomic points.
c. Points defined in pairs: e.g. the two gonions used to measure mandibular width in the PA projection.

Intersection of Edges of Regression as "Points"

"Points" defined as the intersection of images are really lines looked at down their length. For instance, articulare (Ar) and Pterygomaxillary fissure (Ptm) are not points at all and are in no way part of the solid skull. Such "points" exist only in projections and are dependent on subject positioning.

Intersection of Constructed Lines

Intersections of constructed lines are used as "Points", e.g. "Gonion" sometimes is defined as the intersection of the ramal and mandibular lines.

POINTS AND LANDMARKS—DESCRIBED IN THE LATERAL PROJECTION (Fig. 9.9)

Precise definitions of the points and measures used in current cephalometrics is important for improved use in practice. The universal acceptance of definitions will enable clinicians from different orthodontic schools to communicate and understand each other more accurately. All definitions are for easy understanding and may at times vary for a particular analysis.

UNILATERAL LANDMARKS

Nasion (Na) (Fig. 9.10)

The frontonasal suture at its most superior point on the curve at the bridge of the nose.

Anterior Nasal Spine (ANS) (Fig. 9.11)

The most anterior point on the maxilla at the level of the palate.

Superior Prosthion (SPr or PR) (Fig. 9.12)

Also termed supradentale. The most anterior inferior point on the maxillary alveolar process, usually found near the cementoenamel junction of the maxillary central incisor.

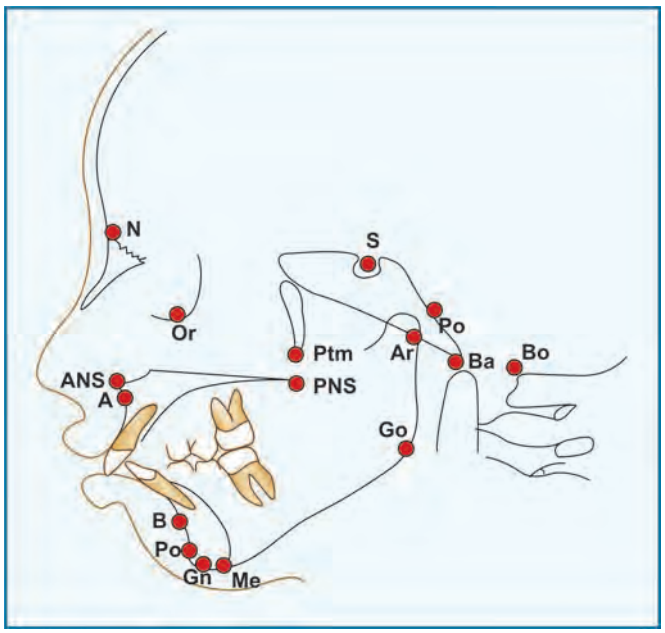


Fig. 9.9: Commonly used landmarks in cephalometrics

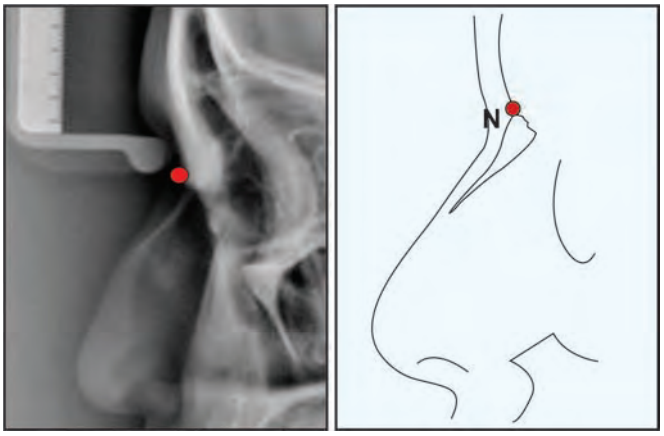


Fig. 9.10: Nasion

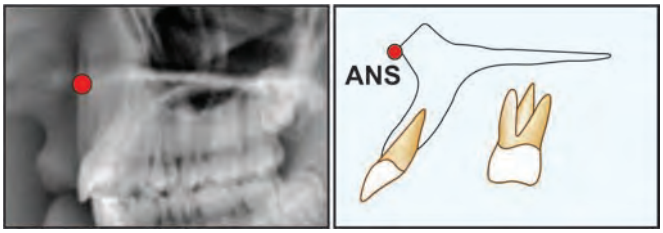


Fig. 9.11: Anterior nasal spine or ANS (red dot)

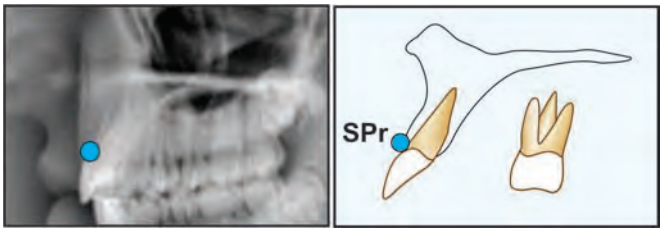


Fig. 9.12: Superior prosthion or supradentale or point SPr (blue dot)

Subspinale ("A" Point) (Fig. 9.13)

The most posterior point on the curve between ANS and PR (SPr). "A" point is usually found 2 mm anterior to the apices of the maxillary central incisor root.

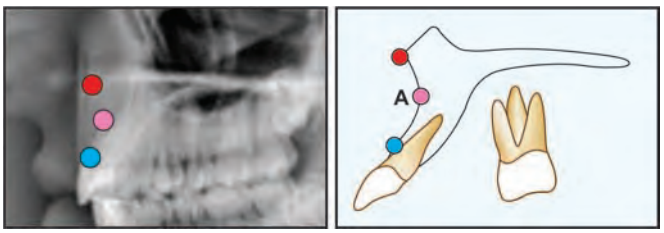


Fig. 9.13: Subspinale or Point "A" (pink dot)

Incision Superius (Is) (Fig. 9.14)

The incisal tip of the most anterior maxillary central incisor.

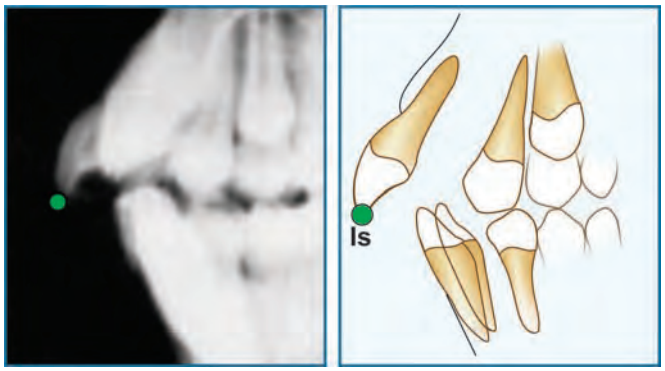


Fig. 9.14: Incision superius

Incision Inferius (Ii) (Fig. 9.15)

The incisal tip of the most labial mandibular central incisor.

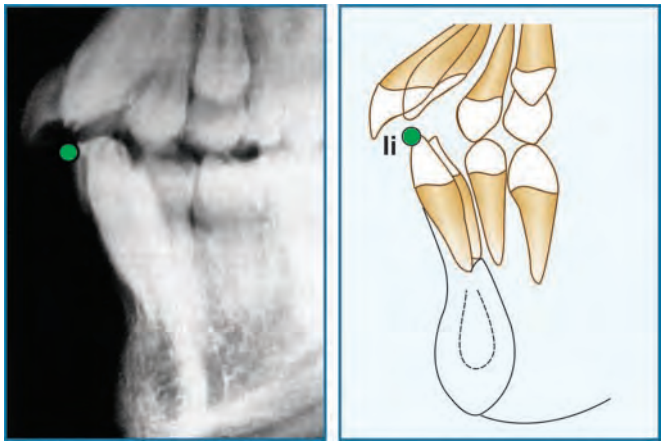


Fig. 9.15: Incision inferius (green dot)

Infradentale (Id) (Fig. 9.16)

The most anterosuperior point on the mandibular alveolar process usually found near the cemento-enamel junction of the mandibular central incisor. Also termed inferior prosthion.

Supramentale ("B" point) (Fig. 9.17)

The most posterior point of the bony curvature of the mandible below infradentale and above Pogonion. "B" point is usually found near the apical third of the roots

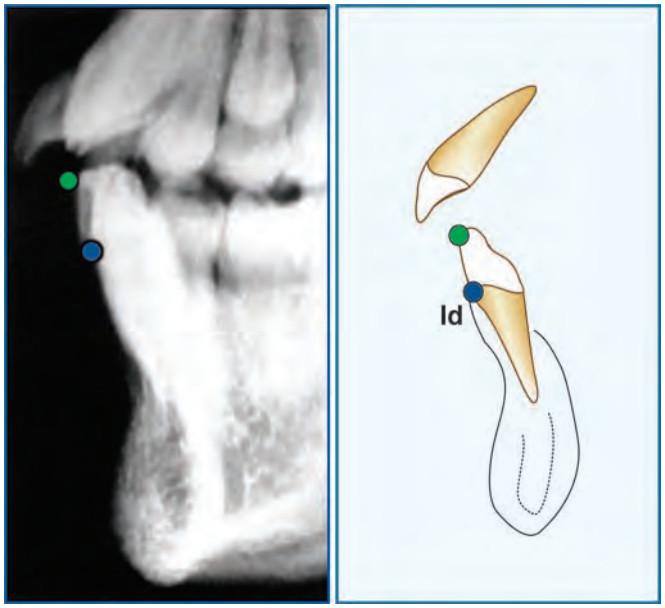


Fig. 9.16: Infradentale (Id) or inferior prosthion (blue dot)

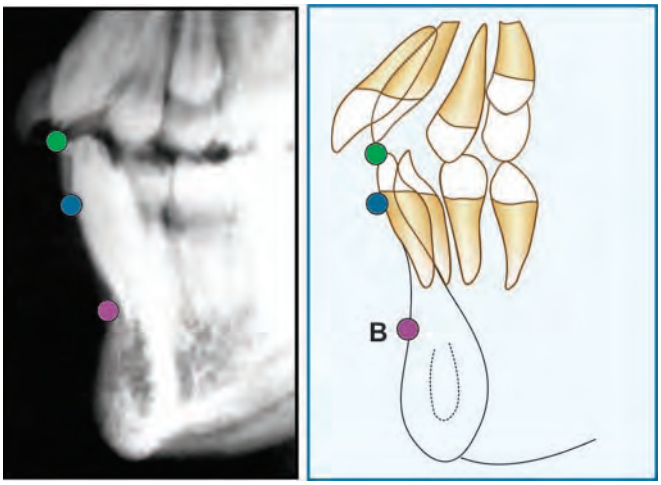


Fig. 9.17: Point "B" (pink dot)

of the mandibular incisors and may be obscured during the eruption of these teeth. When the profile of the chin is not concave, "B" point cannot be determined.

Pogonion (Pog) (Fig. 9.18)

Pogonion is the most anterior point on the contour of the chin. Pogonion usually is located by a tangent perpendicular to the mandibular line or a tangent dropped to the chin from nasion.

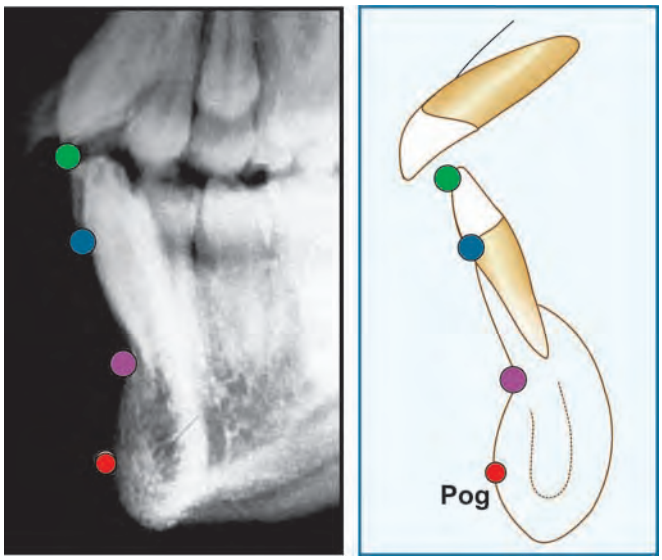


Fig. 9.18: Pogonion (Pog) (red dot)

Menton (Me) (Fig. 9.19)

Menton is the lowest point on the symphyseal outline of the chin.

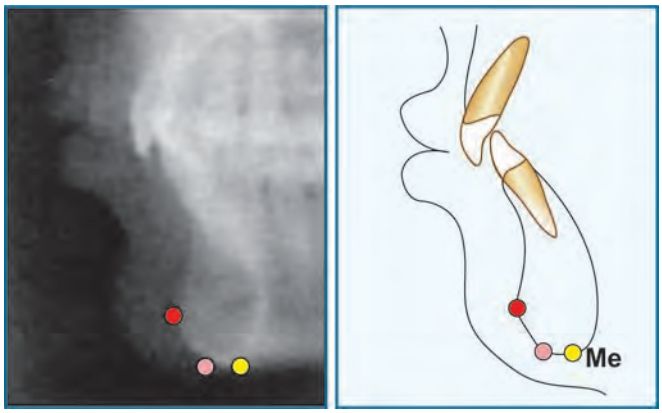


Fig. 9.19: Menton (yellow dot); Gnathion (orange dot); Pogonion (red dot)

Gnathion (Gn) (Fig. 9.20)

The most anteroinferior point on the lateral shadow of the chin. Gnathion may be approximated by the midpoint between pogonion and menton on the contour of the chin.

Basion (Ba) (Fig. 9. 21)

The most inferoposterior point in the sagittal plane on the anterior rim of the foramen magnum—the tip of the posterior cranial base.

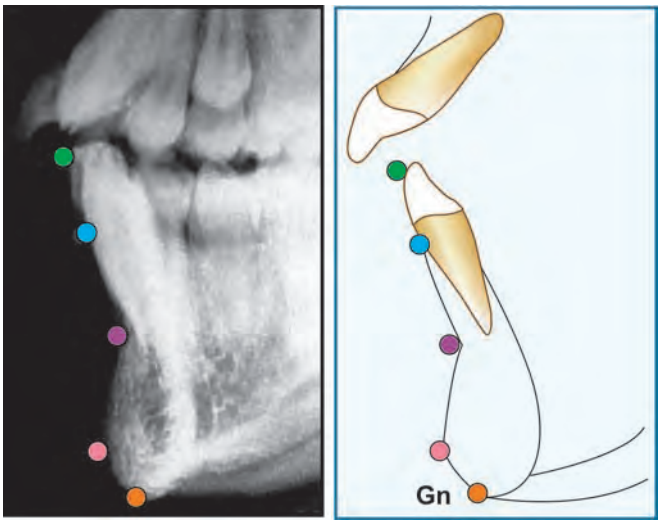


Fig. 9.20: Gnathion (orange dot)

Bolton Point (BO)

The highest point in the upward curvature of the retrocondylar fossa (according to broadbend).

Posterior Nasal Spine (PNS) (Fig. 9.22)

The most posterior point on the bony hard plate in the sagittal plane: usually the meeting point of the inferior and superior surfaces of the hard plate.

Sella(S) (Fig. 9.23)

The center of the hypophyseal fossa (sella turcica). It is selected by the eye, since that procedure has been shown to be as reliable as a constructed center.

BILATERAL LANDMARKS

Orbitale (Or) (Fig. 9.24)

Orbitale has been defined as the lowest point of the bony orbit. In the PA cephalogram, each may be identified but in the lateral cephalograms, the outlines of the orbital rims overlap. Usually, the lowest point on the average outline is used to construct the Frankfort plane.

Gonion (Go) (Fig. 9.25)

Gonion is the most posteroinferior point at the angle of the mandible. It may be determined by inspection or by bisecting the angle formed by the junction of the ramal and mandibular lines, and extending this bisector through the mandibular border.

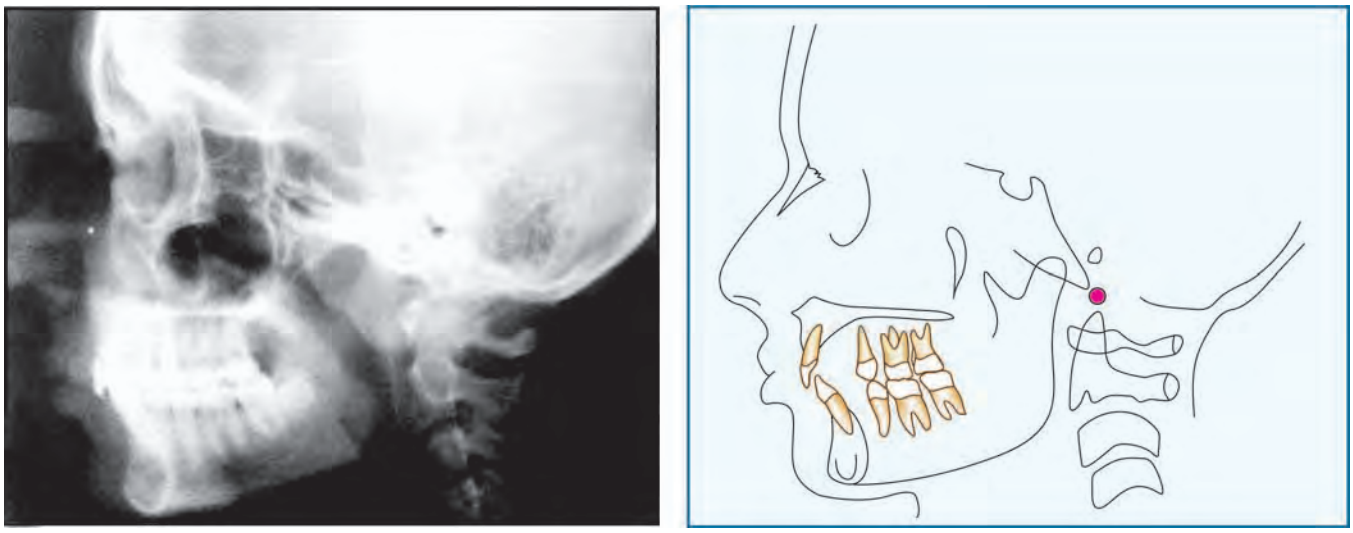


Fig. 9.21: Basion (Ba) (pink dot)

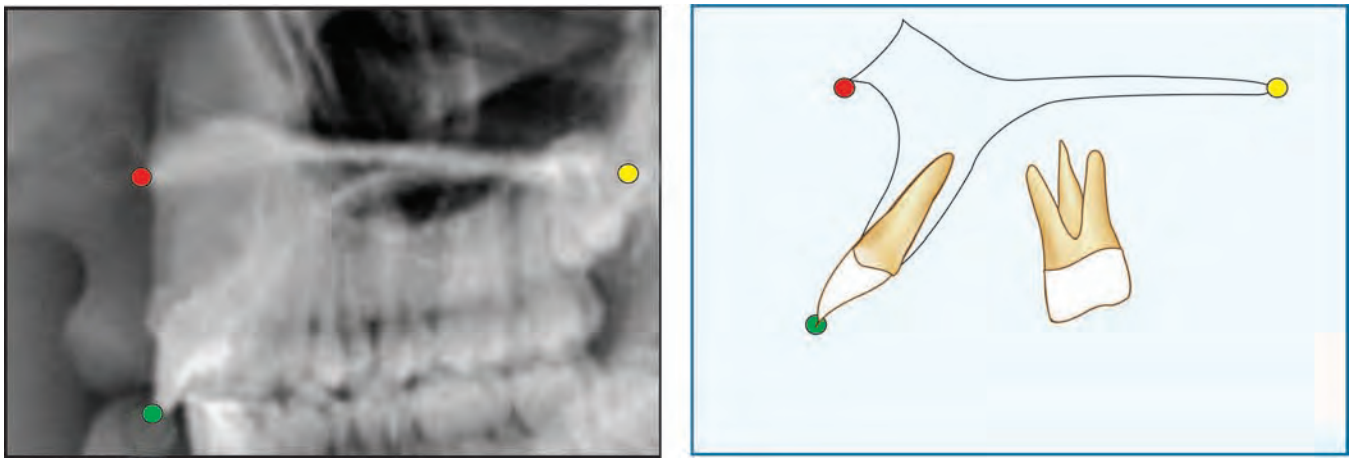


Fig. 9.22: **Posterior nasal spine (PNS) (yellow dot);** also seen is Incision superius (green dot) and ANS (red dot)

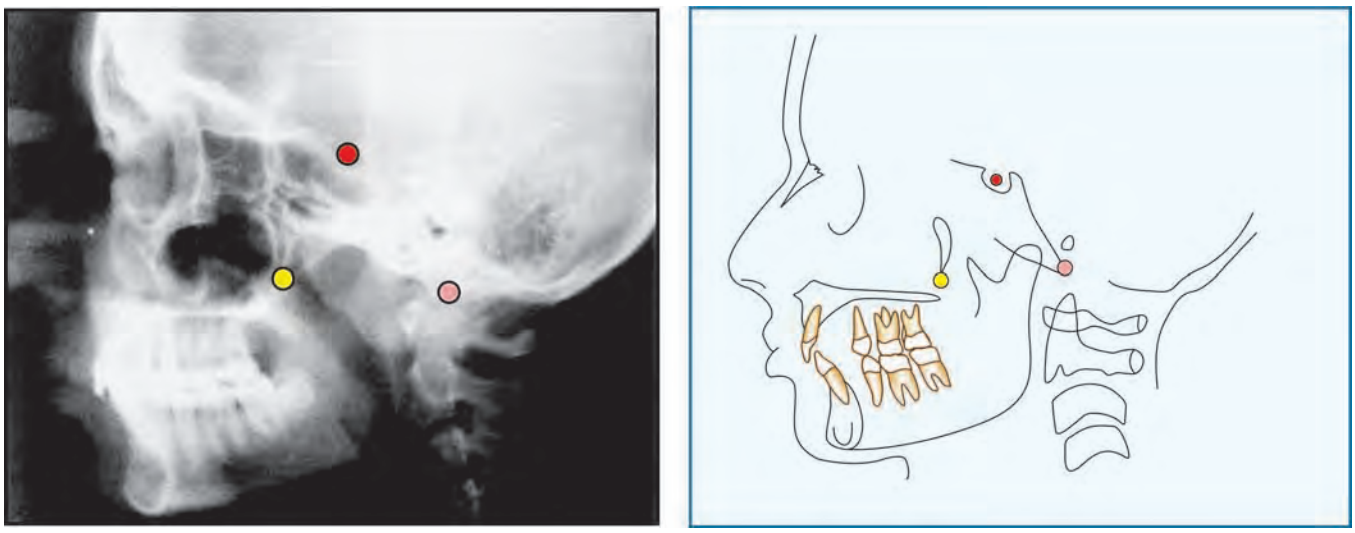


Fig. 9.23: **Sella (S) (red dot);** also seen are Basion (Ba pink dot), Ptm (yellow dot)

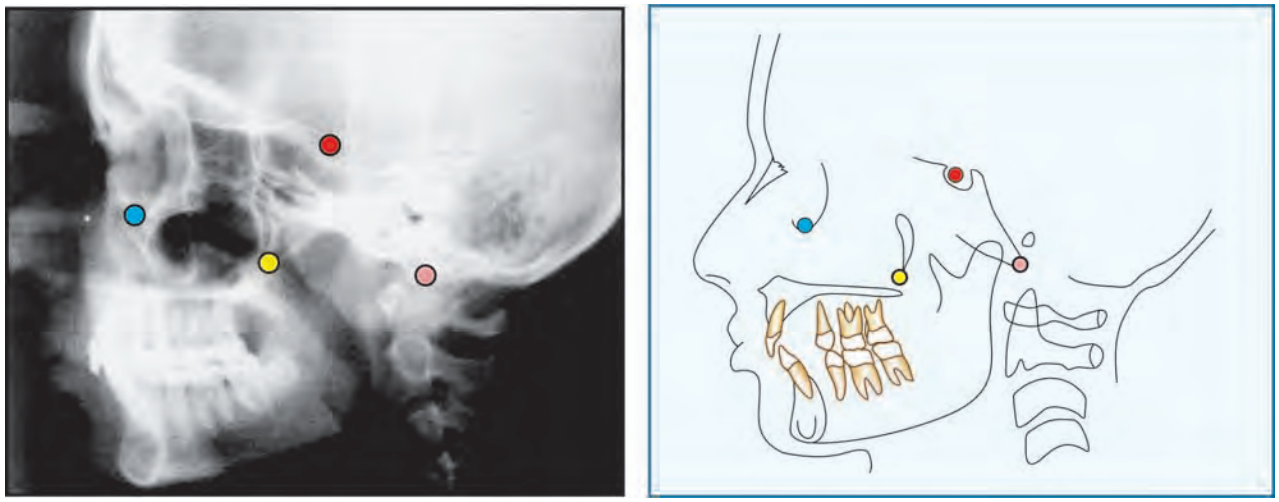


Fig. 9.24: **Orbitale (Or) (sky blue dot);** also seen Basion (Ba pink dot) and Sella (red dot)

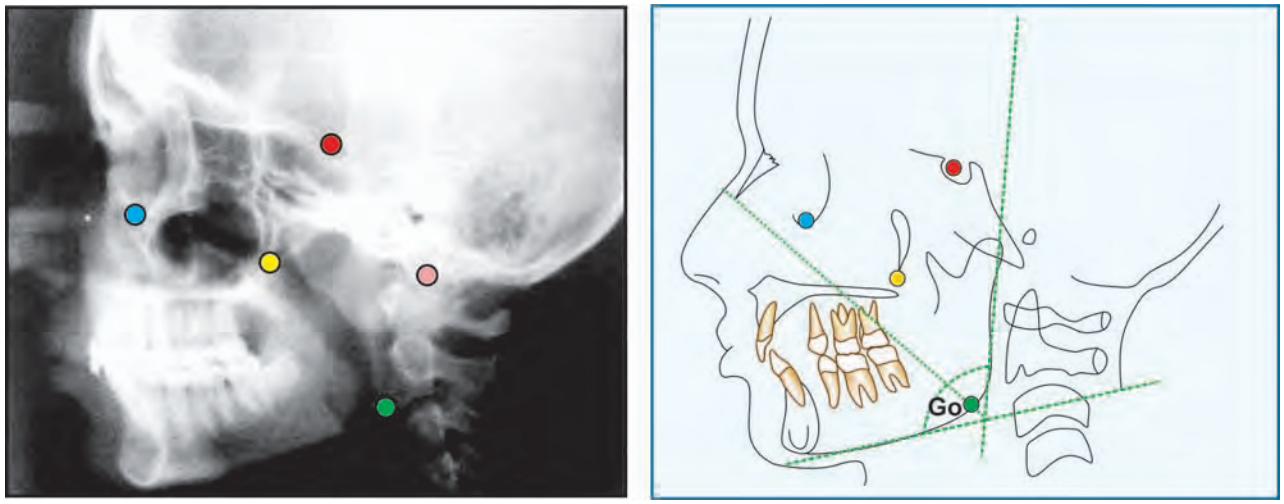


Fig. 9.25: Gonion (Go) (green dot)

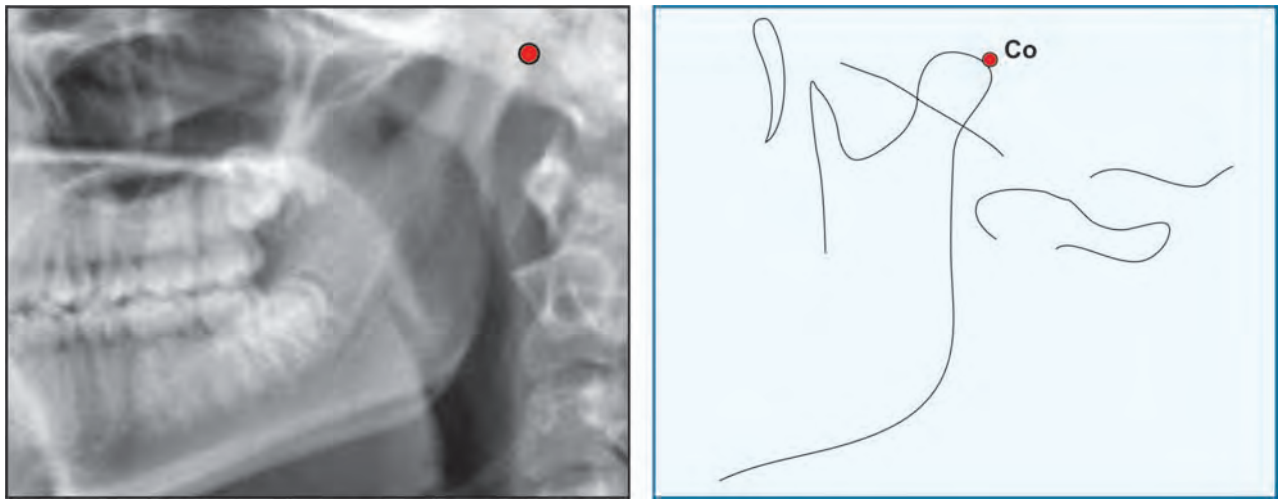


Fig. 9.26: The condylion

Condylion (Co) (Fig. 9.26)

Condylion is the most posterosuperior point on the condyle of the mandible.

Articulare (Ar) (Fig. 9.27)

The intersection of the three radiographic shadows: the inferior surface of the cranial base and the posterior surfaces of the necks of the condyles of the mandible. Articulare is systematically used for condylion when the latter is not reliably discernible. Displacement of the condyle moves the articulare.

Pterygomaxillary Fissure (Ptm) (Fig. 9.28)

A bilateral teardrop-shaped area of radiolucency, the anterior shadow of which is the posterior surfaces of the tuberosities of the maxilla. The PTM point is the intersection of the inferior border of the foramen rotundum with the posterior wall of the pterygo-maxillary fissure.

Porion (Po) (Fig. 9.29)

The "top" of the external auditory meatus. Sometimes, because porion is quite unreliable, the "top" of the

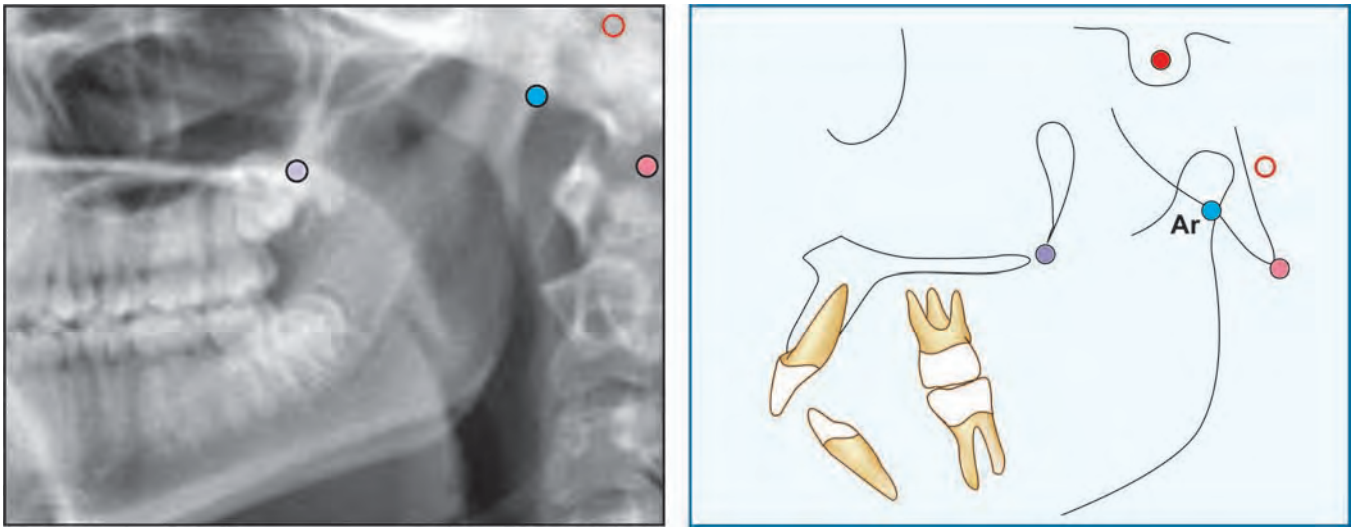


Fig. 9.27: Articulare (Ar, blue dot), Basion (Ba pink dot), Sella (red dot), Ptm point (violet dot), Porion (red circle)

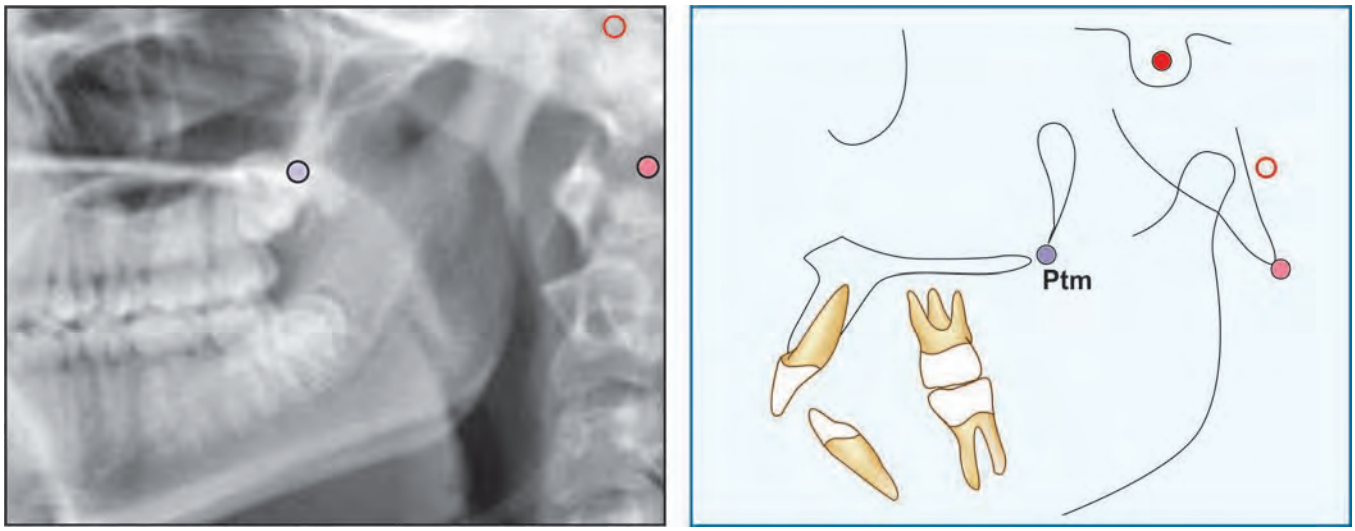


Fig. 9.28: Ptm point (violet dot) also seen is Sella (red dot)

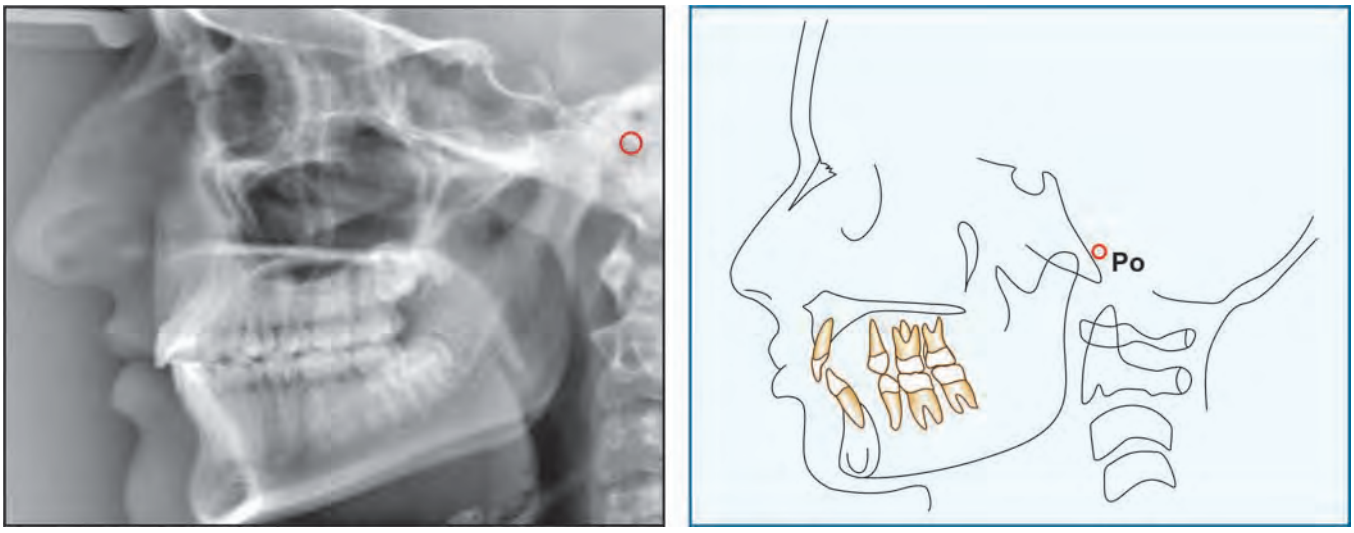


Fig. 9.29: Porion (Po)

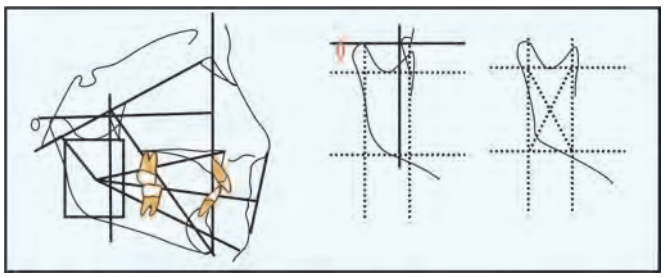


Fig. 9.30: Porion (Po)

shadow of the ear rods is used, which is known as "machine porion".

Xi-Point (Fig. 9.30)

A point located at the geometric center of the ramus. Location of Xi is keyed geometrically to PO-OR (FH) and perpendicular through PT (PTV) in the following steps:

1. By construction of planes perpendicular to FH and PTV
2. These constructed planes are tangents of points (R1, R2, R3, R4) on the borders of the ramus.
3. The constructed planes form a rectangle enclosing the ramus.
4. Xi is located in the center of the rectangle at the intersection of diagonals.

R1-Mandible

R1 is the deepest point on the curve of the anterior border of the ramus, one-half the distance between the inferior and superior curves.

R2-Mandible

R2 is located on the posterior border of the ramus of the mandible.

R3-Mandible

R3 is located at the center and most inferior aspect of the sigmoid notch of the ramus of the mandible.

R4-Mandible

R4 is a point on the border of the mandible directly inferior to the center of the sigmoid notch of the ramus.

COMMONLY USED LINES AND PLANES DESCRIBED IN THE LATERAL PROJECTION

Frankfort Horizontal Plane

Used first by Down, it is drawn from the point orbitale to the superiormost point on the external auditory meatus (Porion). (Fig. 9. 31, yellow line).

S-N Line

The S-N line represents the anterior cranial base. It is constructed by connecting the points sella turcica and the Nasion (Fig. 9.31, red line).

Bolton's Plane

This plane is constructed by extending a line from the Bolton's point to Nasion (Fig. 9.31, pink line).

Palatal Plane

The palatal plane is drawn by extending a line from the anterior nasal spine (ANS) to posterior nasal spine (PNS) (Fig. 9.31, sky blue line).

Occlusal Plane (Functional OP, Anatomic OP)

It was originally described by Down as the line connecting the molars in occlusion to the bisector of the overbite (vertical overlap of the incisors anteriorly), also know as the **anatomic occlusal plane**. It was later modified to be represented by the line passing through the occlusion of the premolars and the molars (Fig. 9.31, orange line), also known as the **functional occlusal plane**.

Mandibular Plane

Mandibular planes have been defined by various authors based upon their clinical experience and use in their cephalometric analyses.

Tweed described the mandibular plane as a line that is a tangent to the inferior border of the mandible.

Down considered the mandibular plane to represent a line connecting the points gonion and menton.

Steiner drew the mandibular plane by joining the points Gonion and Gnathion.

DOWN'S ANALYSIS

INTRODUCTION

For us to be able to derive any meaningful conclusions from the study of cephalograms, it is essential to have certain standards against which to compare the data obtained after analyzing the patient's cephalogram. One of the first and also one of the most commonly used data / analysis was provided by Down.

Down divided his analysis into two components. The skeletal component helped in defining the underlying facial type and the dental component is used to establish if the dentition is placed normally in relation to the underlying bony structures.

Down classified the face into four basic types –

- *Retrognathic*- a regressive or retruded lower jaw.
- *Mesognathic*- an "ideal" or average position of the lower jaw.
- *Prognathic*- a protrusive lower jaw.
- *True prognathism*- a pronounced protrusion of the lower face.

According to Down, any of the above four basic facial types could possess a normal occlusion and a harmonious facial profile, in form and proportion. This did not mean that ideal skeletal profiles could not or did not have dental malrelationships.

Down used the Frankfort-Horizontal plane as the reference plane; as it approximates a near level position when the patient is standing in a posture of distant vision.

Down's Control Group

The control group studied by Down was derived from 20 Caucasian subjects, who ranged in age from 12 to 17 years and were equally divided as to sex. All individuals possessed clinically excellent occlusions.

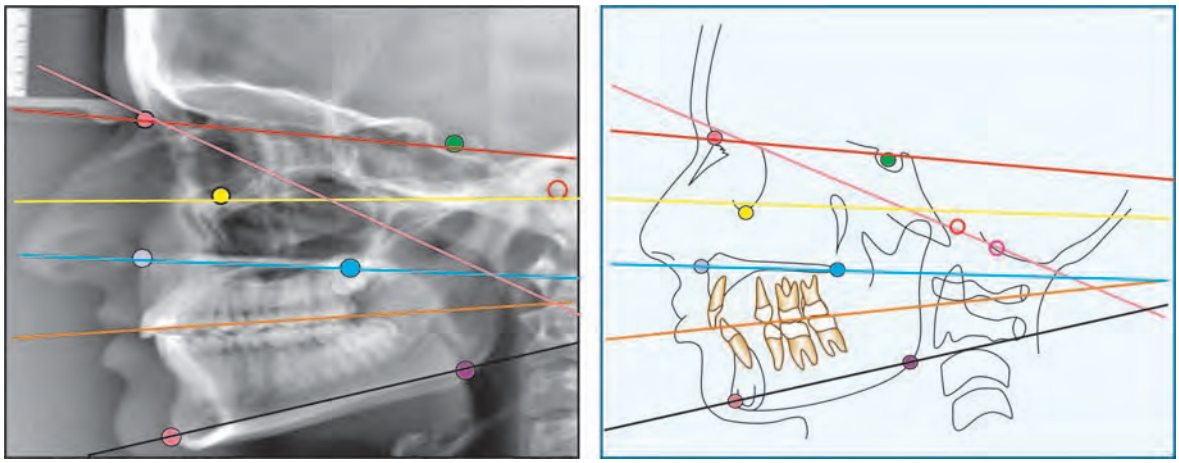


Fig. 9.31: Frankfort plane- yellow line, S-N plane- red line, Bolton's plane- pink line, palatal plane- blue line, occlusal plane- orange line, mandibular plane (Go- Gn)-black line

SKELETAL PARAMETERS

Facial Angle

The facial angle is used to measure the degree of retrusion or protrusion of the lower jaw. The facial angle provides an indication of the degree of recession or protrusion of the mandible in relation to the upper face. Facial angle is the inferior inside angle formed by the intersection of the facial line (Nasion-Pogonion) to the Frankfort Horizontal (FH) Plane (Fig. 9.32A)

The mean reading for this angle is 87.8° (± 3.6°) with a range of 82° to 95°.

A prominent chin increases this angle, whereas a smaller than average angular reading suggests a retrusive or retropositioned chin.

Angle of Convexity

The angle of convexity is formed by the intersection of line N-point A to point A-Pogonion (Fig. 9.32B).

This angle measures the placement of the maxillary basal arch at its anterior limit (point A) relative to the total facial profile (Nasion-Pogonion).

This angle is read in plus or minus degrees starting from zero. If the line Pogonion-point A is extended and located anterior to the N-A line, the angle is read as positive. A positive angle suggests prominence of the maxillary denture base relative to the mandible. A negative angle of convexity is associated with prognathic profile or in other words a Class III profile.

The range extends from –8.5° to +10°, with a mean of 0°.

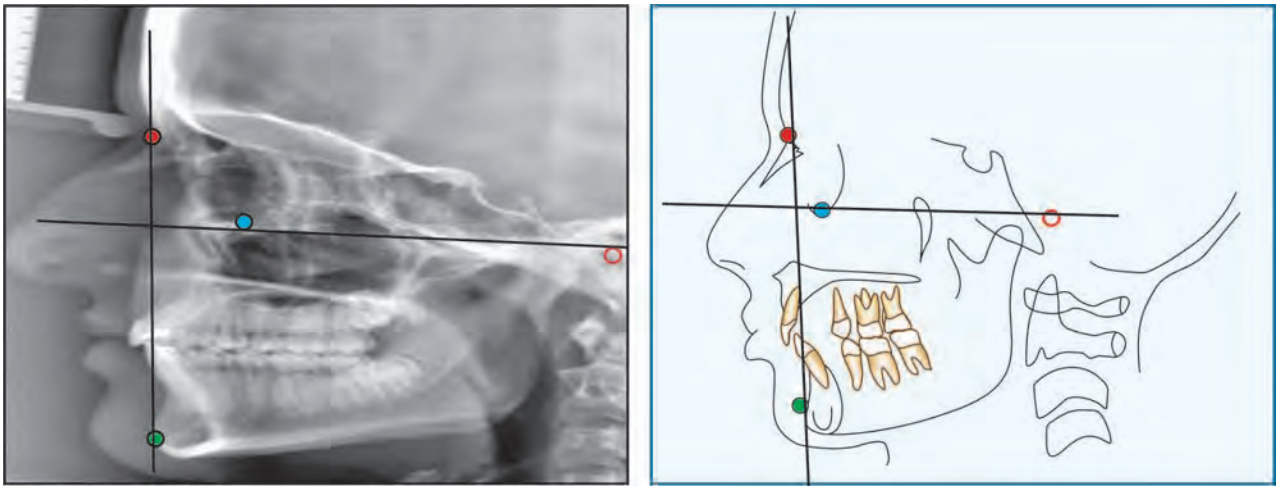


Fig. 9.32A: Facial angle—an average of 87.8° + 3.6° (Nasion-red dot, Pogonion-green dot, Porion-red circle, orbitale-blue dot)

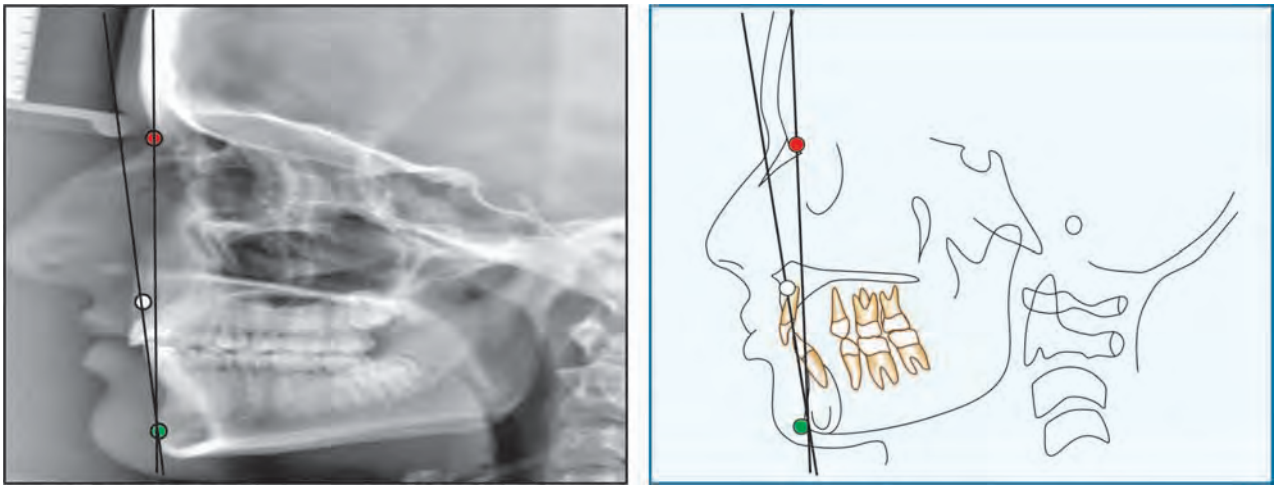


Fig. 9.32B: Angle of convexity—the average value is 0° + (Nasion- red dot, Pogonion- green dot, 'A' point- white dot)

A-B Plane Angle

Points A and B are joined by a line which when extended forms an angle with the line Nasion-Pogonion, this is called the A-B plane angle (Fig. 9.32C).

The A-B plane is a measure of the relation of the anterior limit of the apical bases to each jaw relative to the facial line. Generally point B is positioned behind point A thus this angle is usually negative in value, except in Class III malocclusions or Class I occlusions with prominence of the mandible.

A large negative value suggests a Class II facial pattern, which can be due to the retro-positioned chin or mandible or underdeveloped chin point or a prominent maxilla, i.e. point B located behind point A.

The range extends from a maximum of 0° to a minimum of –9° with a mean reading of –4.6°.

Mandibular Plane Angle

The mandibular plane according to Down, is a "tangent to the gonial angle and the lowest point of the symphysis". (Some authors describe the mandibular plane as the line joining the gonion and the gnathion). The mandibular plane angle is established by relating the mandibular plane to the Frankfort Horizontal plane (Fig. 9.32D).

High mandibular plane angles occur in both retrusive and protrusive faces and are suggestive of unfavorable hyperdivergent facial patterns or 'long face cases'.

The range extends from a minimum of 17° to a maximum of 28° with a mean of 21.9°.

Y-(Growth) Axis

The growth axis is measured as an acute angle formed by the intersection of a line from sella turcica to Gnathion with the Frankfort horizontal plane (Fig.9.32E).

This angle is larger in Class II facial patterns than in those with Class III tendencies. It indicates the degree of downward, rear ward or forward position of the chin in relation to the upper face.

A decrease of the Y-axis in serial radiographs may be interpreted as a greater horizontal than vertical growth of the face or a deepening of the bite in orthodontic cases. An increase in the Y-axis is suggestive of vertical growth exceeding horizontal growth of the mandible or an opening of the bite during orthodontic treatment. The Y-axis reading also increases with the extrusion of the molars (this is generally desirable when correcting malocclusions in horizontal growers.

The range extends from a minimum of 53° to a maximum of 66° with a mean reading of 59.4°.

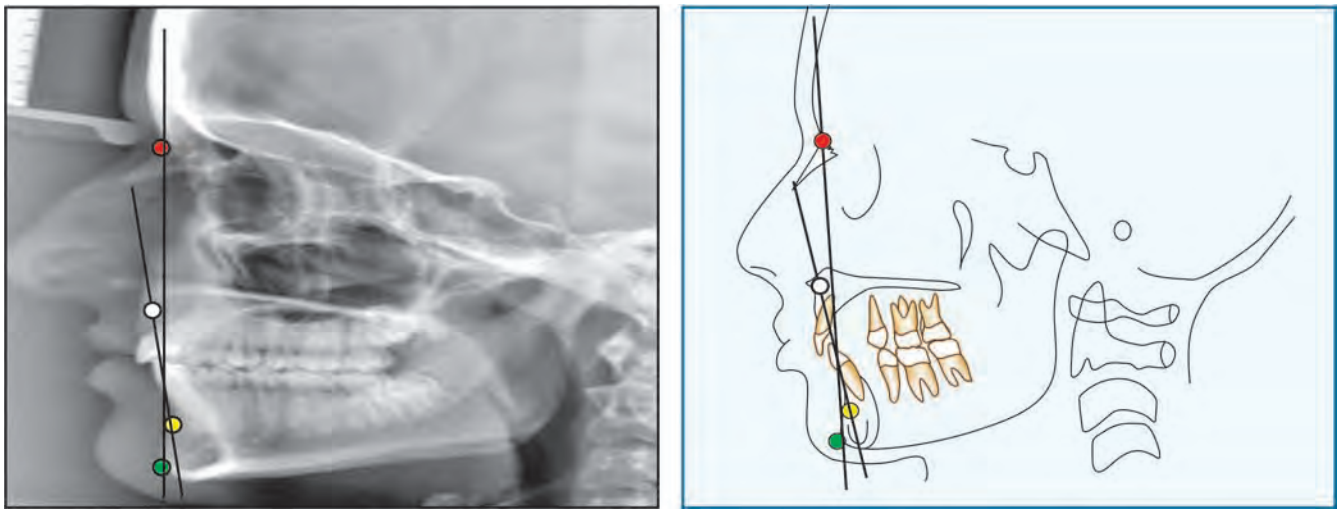


Fig. 9.32C: A-B Plane Angle—has a mean value of –4.6° (Nasion- red dot, Pogonion-green dot, 'A' point- white dot 'B' Point- yellow point)

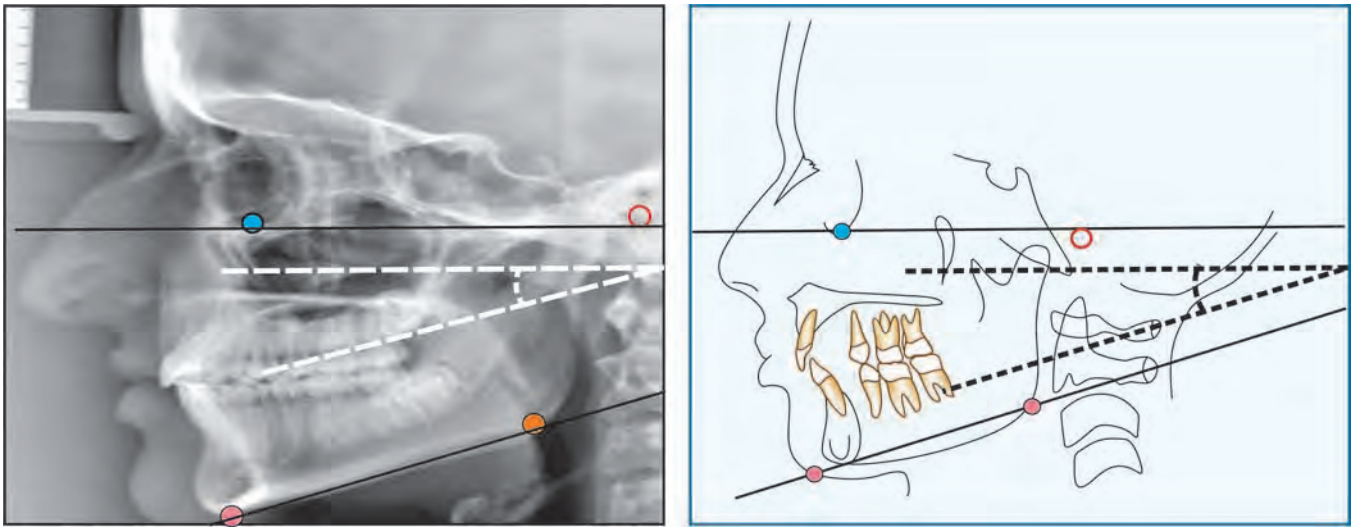


Fig. 9.32D: Mandibular plane angle—mean value of 21.9° (Porion- red circle, Orbitale- blue dot , Gonial angle—orange dot, Pink point is the lowest point of the symphysis)

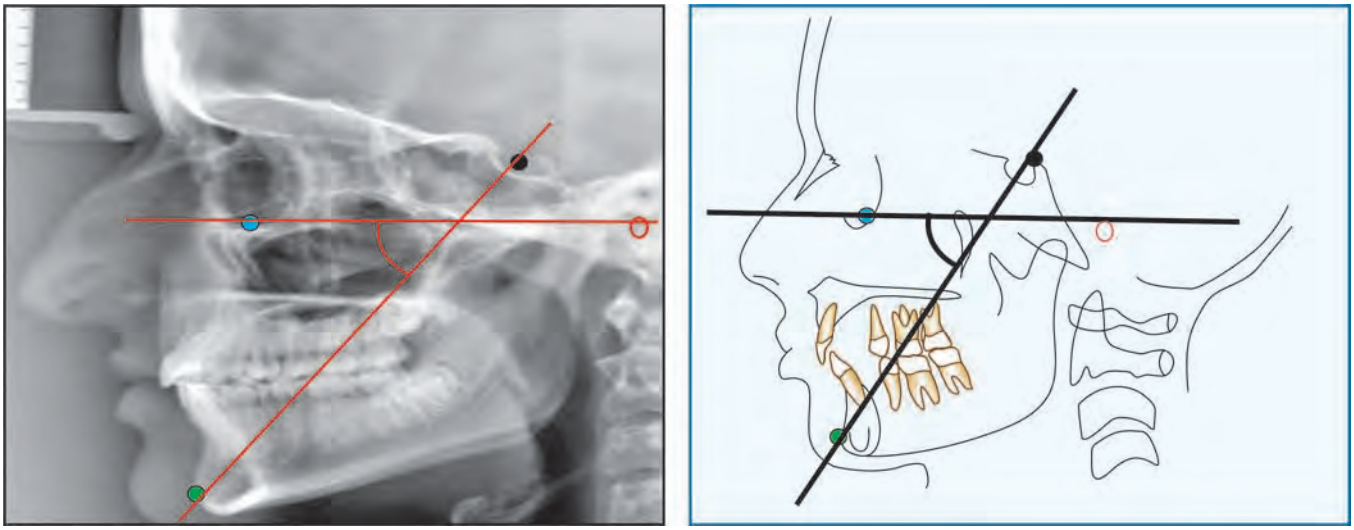


Fig. 9.32E: Growth axis—mean of 59.4° (Orbitale- blue dot, Porion-red circle, Sella-black dot, Gnathion- green dot)

DENTAL PARAMETERS

Cant of Occlusal Plane

Down originally defined it as the line bisecting the overlapping cusps of the first molars and the incisal overbite.

Cases in which the incisors are grossly malpositioned, Down recommended drawing the occlusal plane through the region of the overlapping cusps of the first premolar and first molars (Fig. 9.32F).

The Cant measures the slope of the occlusal plane to the Frankfort Horizontal plane. When the anterior part of the plane is lower than the posterior, the angle would be positive. Large positive angles are found in Class II facial patterns. A long mandibular ramus also tends to decrease this angle.

The mean value is +9.3° with a range of +1.5° to +9.3°.

Inter-incisal Angle

The inter-incisal angle is established by passing a line through the incisal edge and the apex of the root of the maxillary and mandibular central incisors (Fig. 9.32G).

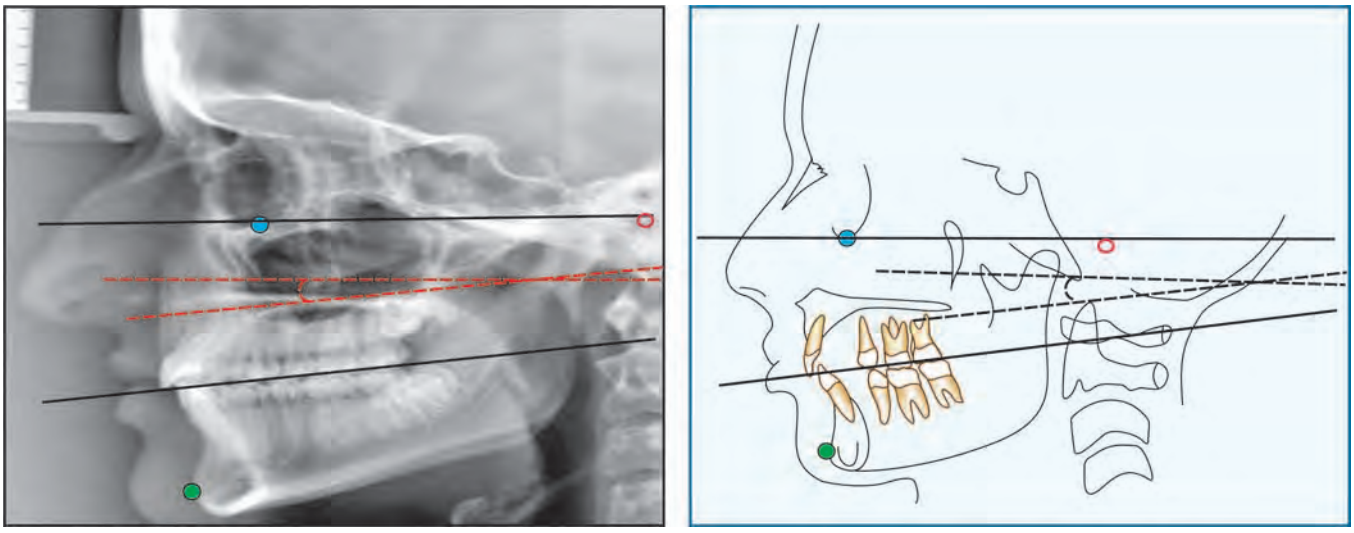


Fig. 9.32F: Cant of occlusion—mean value of +9.3° (Orbitale- blue dot, porion- red circle)

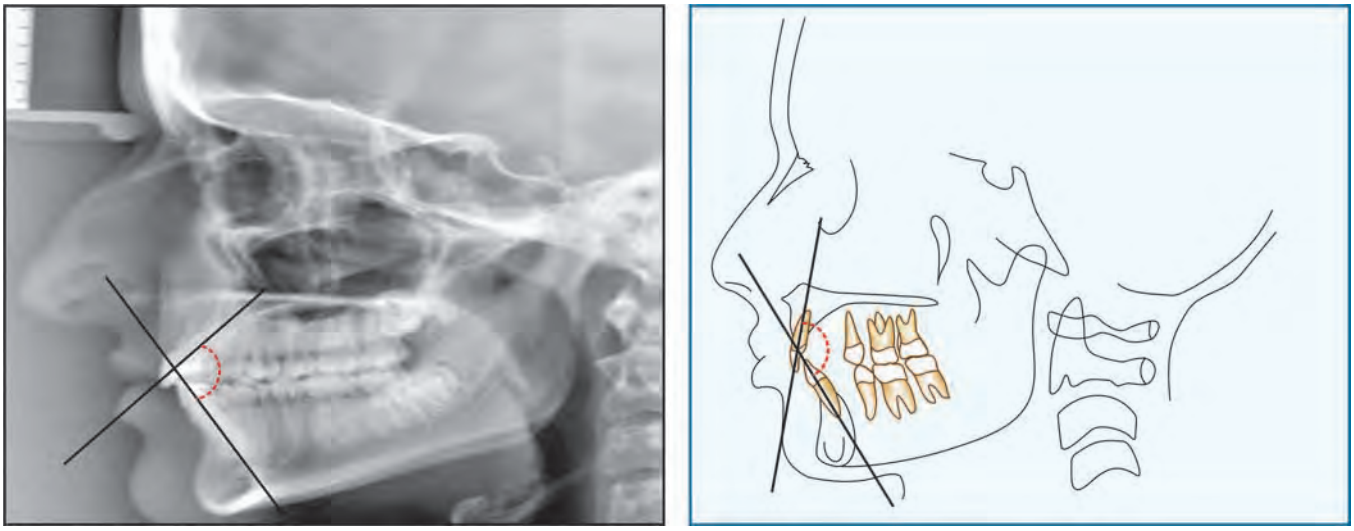


Fig. 9.32G: Inter-incisal angle—a mean of 135.4°

The inter-incisal angle is relatively small in individuals whose incisors are tipped forward on the denture base, i.e. they are proclined.

The mean value is 135.4°, with a range of 130° to 150°.

Incisor Occlusal Plane Angle

This angle relates the lower incisors to their functioning surface at the occlusal plane. The inferior inside angle is read as a plus or minus deviation from the right angle (Fig. 9.32H).

The positive angle increases as these teeth incline forward, i.e. become proclined. The values are least in class II div. 2 cases where the incisors are retroclined.

The mean value is 14.5° with a standard deviation of ±3.5° and a range of +3.5° to +20°.

Incisor Mandibular Plane Angle

It is formed by the intersection of the mandibular plane with a line passing through the incisal edge and apex of the root of the mandibular central incisor (Fig.9.32 I).

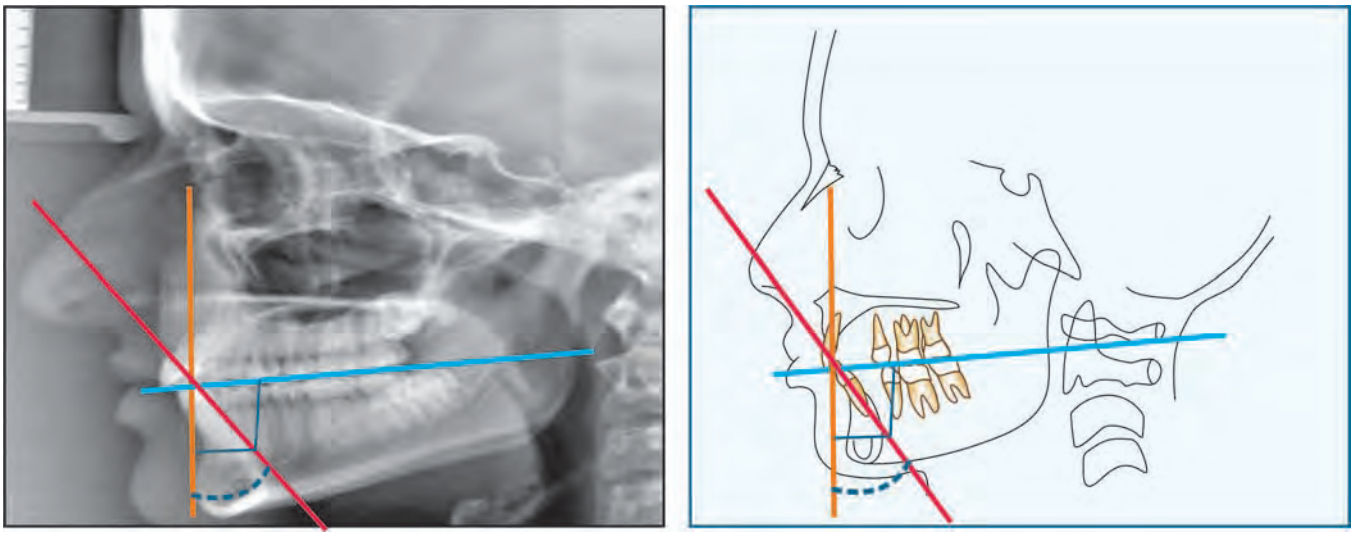


Fig. 9.32H: Mandibular incisor to occlusal plane—mean value of +14.5° (Occlusal plane- blue line, Long axis of the mandibular incisor- orange line)

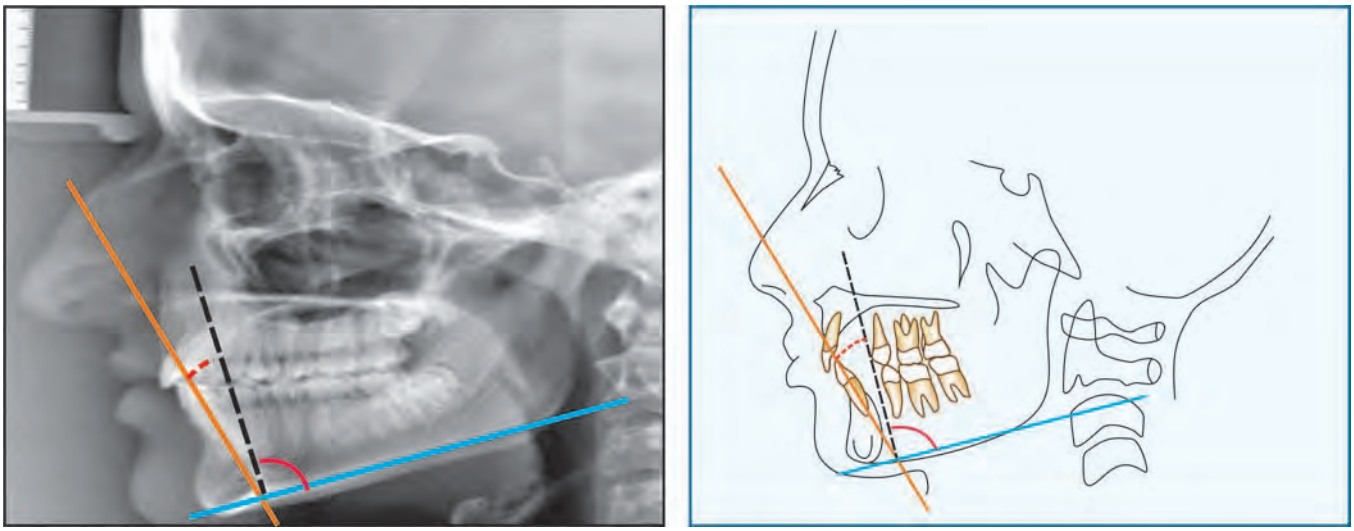


Fig. 9.32I: Incisor mandibular plane angle 1.4° (Mandibular plane angle-blue line, long axis of the mandibular incisor-orange line)

The angle is positive when the incisors are tipped forward on the denture base, i.e. they are proclined forward. The value increases as the proclination increases.

The mean value is 1.4°with a range of -8.5° to +5°.

Protrusion of Maxillary Incisors

It is measured as the distance between the incisal edge of the maxillary central incisor to the line from Point A to Pogonion (Fig. 9.32 J). This distance is positive if the incisal edge is ahead of the point A-Pogonion line and negative if the incisal edge lies behind this line. It indicates the amount of maxillary dental protrusion.

The mean value is +2.7 mm with a range of –1.0 to +5 mm.

STEINER ANALYSIS

Cecil C. Steiner went a step further when he evolved an analysis that took into account not only the relation of the teeth to each other and to their respective dental

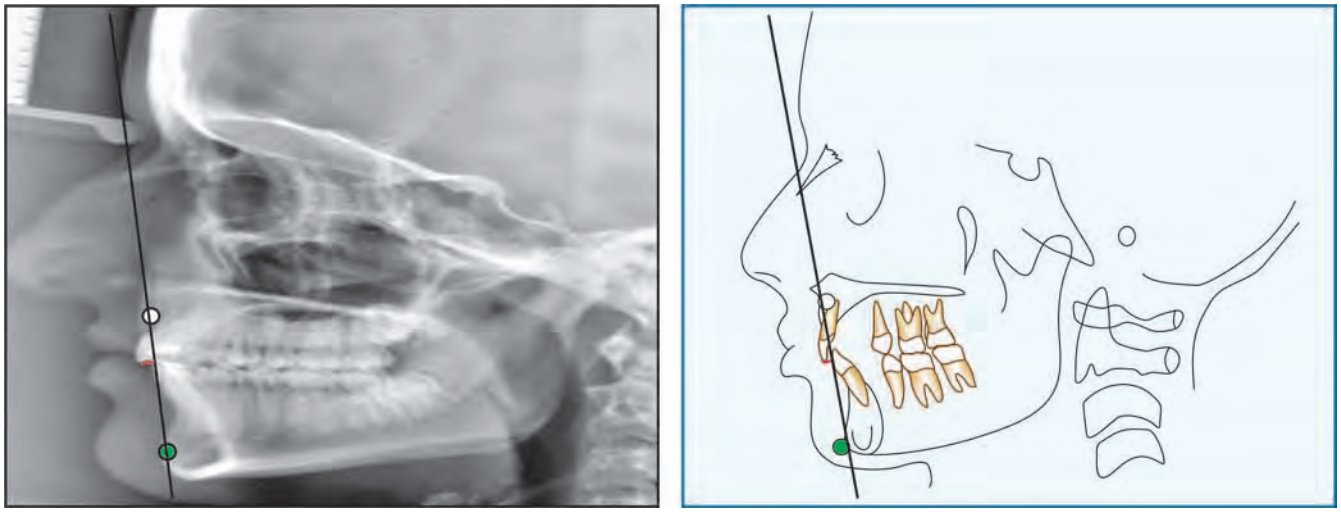


Fig. 9.32J: Protrusion of the maxillary incisor is measured as the horizontal distance of the maxillary incisal tip to the A-Pog line (shown as bold red line in illustration). Mean value of +2.7mm

bases but also recognized the importance of the soft tissue cover and included data to analyze the same. He selected what he considered to be the most meaningful parameters and evolved a composite analysis, which he believed would provide the maximum clinical information with the least number of measurements. By comparing measurements of patients with malocclusions with those of "normal" occlusions, the degree of deviation from the normal could be determined.

THE ANALYSIS

Steiner divided his analysis into three parts—skeletal, dental and soft tissues. Skeletal analysis entails relating the upper and lower jaws to the skull and to each other. The dental analysis entails relating the upper and lower incisor teeth to their respective jaws and to each other. And the soft tissue analysis provides a means of assessing the balance and harmony of the lower facial profile.

Steiner noted that landmarks such as Porion and Orbitale are not always easily identified on lateral cephalometric head films, hence, he elected to use the anterior cranial base (Sella to Nasion) as the line of reference for his analysis. The advantage of using these two midline points is that they are moved only a minimal amount whenever the head deviates from the true profile position. This remains true even if the head is rotated in the cephalostat.

Relating the Maxilla to the Skull

The angle SNA is formed by joining the lines S-N and N-A (Fig. 9.33A).

The mean reading for this angle is 82°.

If the angular reading is more than 82°, it would indicate a relative forward positioning or protrusion of the maxilla. Conversely, should the reading be less than 82°, it would indicate a relative backward or recessive location of the maxilla.

Relating the Mandible to the Skull

To assess whether the mandible is protrusive or recessive relative to the cranial base, the SNB angle is read (Fig. 9.33B). The mean for this angle is 80°.

If the angle is less than 80°, it is indicative of a retruded mandible. An angle greater than 80° degrees suggests a prognathic or forwardly positioned mandible.

Relating the Maxilla to the Mandible

The angle ANB (Fig. 9.33C), provides information on the relative positions of the jaws to each other. The ANB angle provides a general idea of the anteroposterior discrepancy of the maxillary to the mandibular apical bases.

The mean reading for this angle is 2°. A reading greater than 2° indicates a Class II skeletal tendency. As a rule, the larger the figure, the greater the

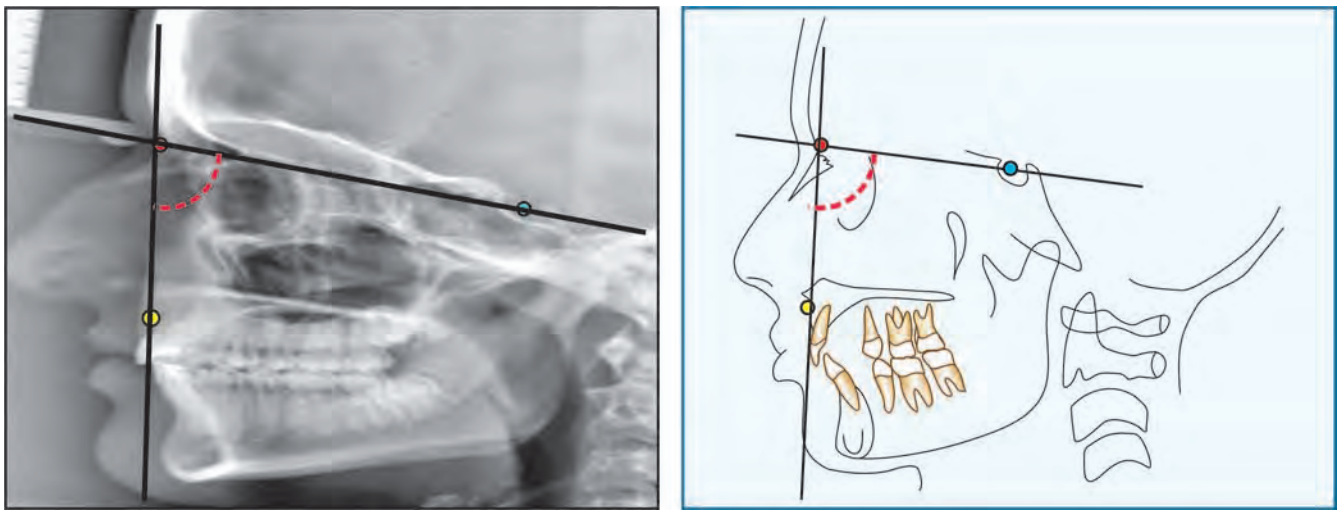


Fig. 9.33A: Angle SNA (Sella turcica-blue dot, Nasion- red dot, A point- yellow dot)

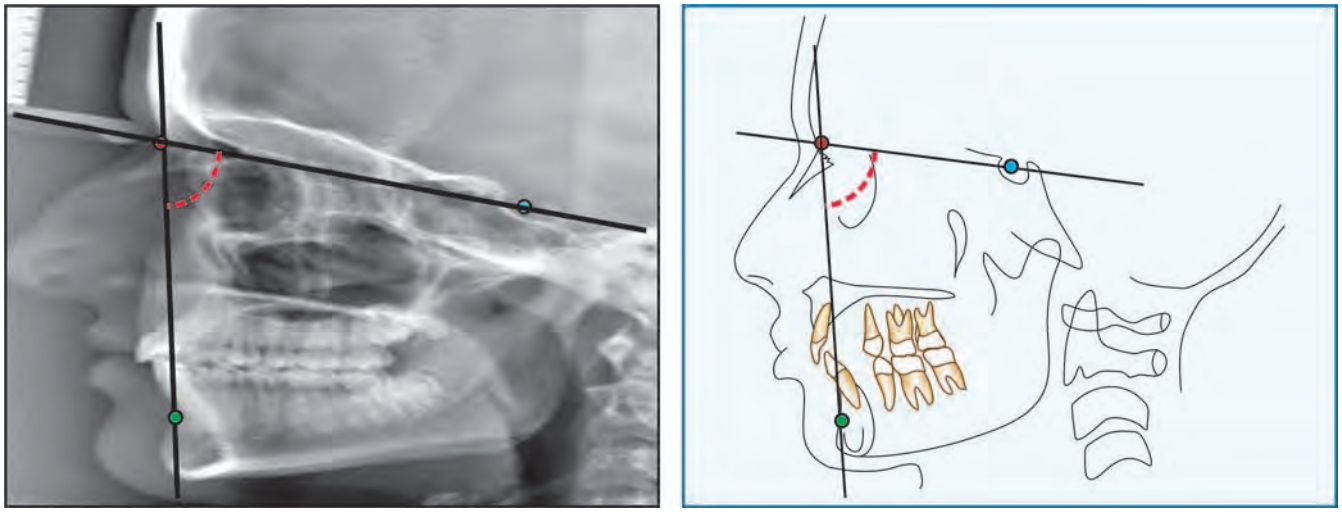


Fig. 9.33B: Angle SNB (Sella turcica-blue dot, Nasion- red dot, B point-green dot)

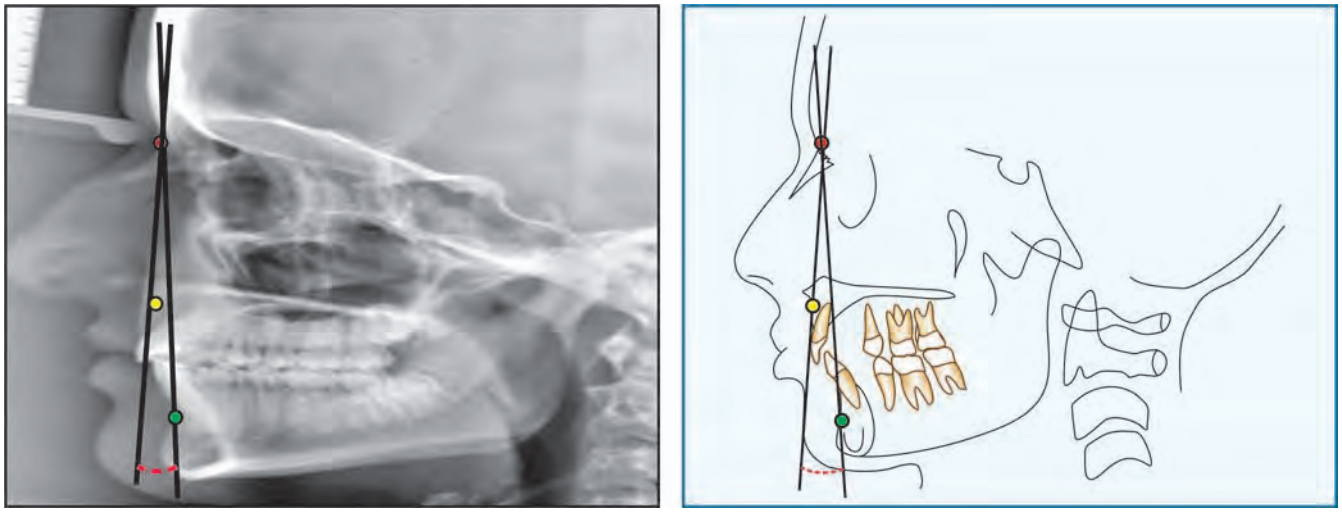


Fig. 9.33C: Angle ANB (Nasion- red dot, A point- yellow dot, B point-green dot)

anteroposterior jaw discrepancy, and hence the greater the difficulty in correcting a malocclusion.

Angles less than 2° and readings of below zero (e.g. -1°, -2°, etc.) indicate that the mandible is located ahead of the maxilla, suggesting a Class III skeletal relationship.

Occlusal Plane Angle

The occlusal plane is drawn through the region of the overlapping cusps of the first premolars and first molars. The angle of the occlusal plane to S-N plane is measured (Fig. 9.33D).

The mean reading for normal occlusions is 14°. The angle is increased in long face or vertically growing individuals and also skeletal open bite cases. It may be decreased in horizontally growing individuals or cases with a skeletal deep bite.

Mandibular Plane Angle

The mandibular plane is drawn between Gonion (Go) and Gnathion (Gn). The mandibular plane angle is formed by joining the mandibular plane to the anterior cranial base (S-N plane) (Fig. 9.33E).

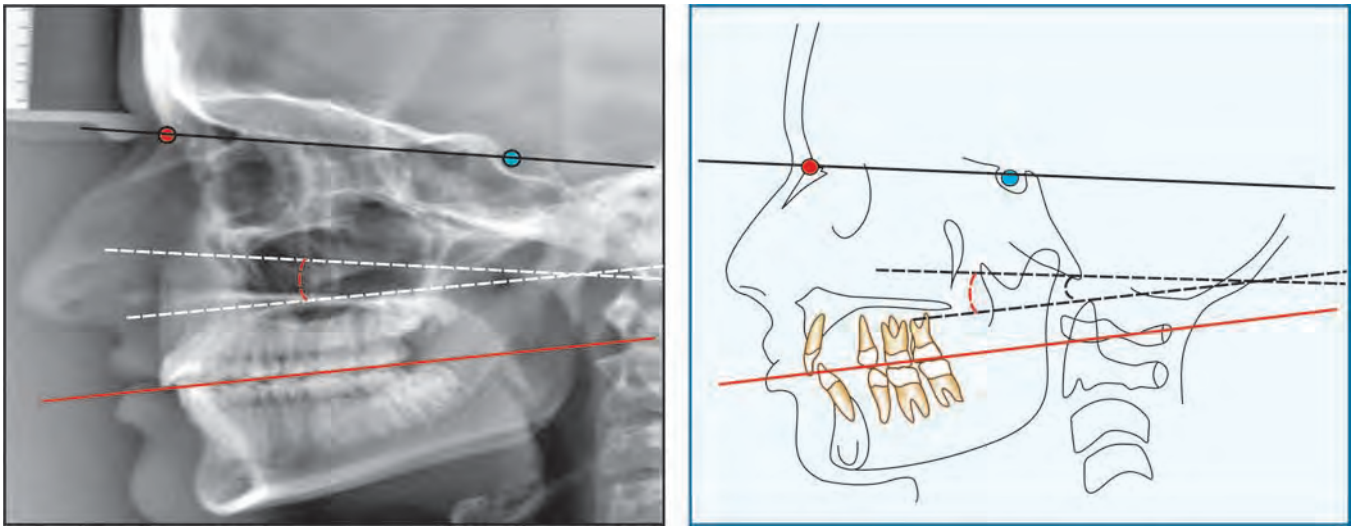


Fig. 9.33D: Occlusal plane angle (Nasion- red dot, Sella turcica- blue dot, Occlusal plane- red line)

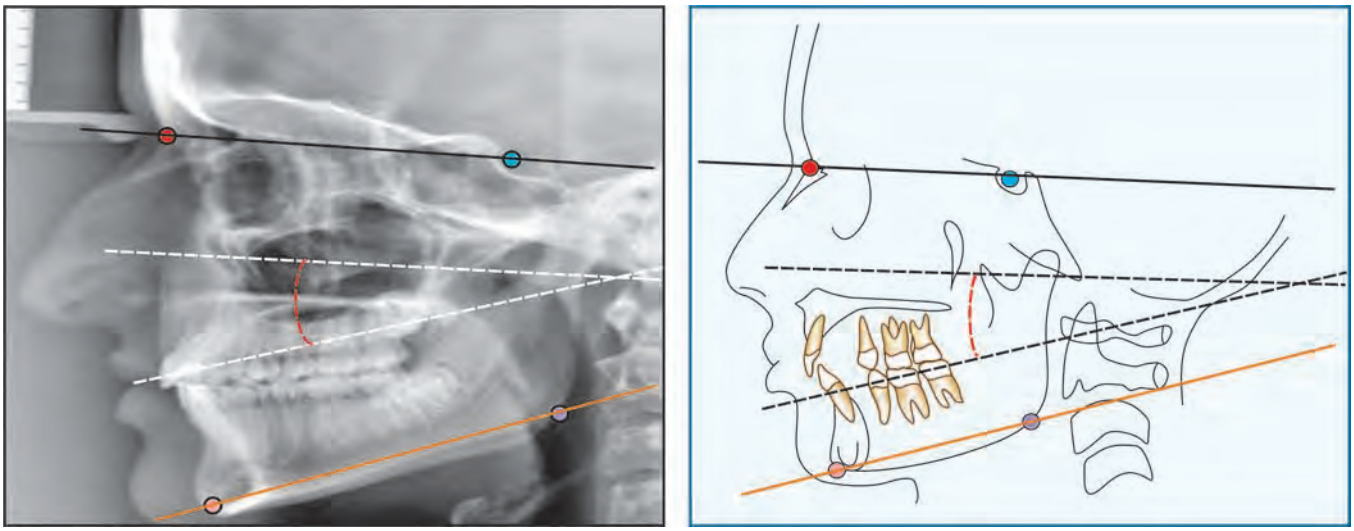


Fig. 9.33E: Mandibular plane angle (Nasion-red dot, Sella turcica-blue dot, Gnathion-pink dot, Gonion- lavender dot, mandibular plane- orange line)

The mean reading for this angle is 32°.

Excessively high (vertical growers) or low (horizontal growers) mandibular plane angles are suggestive of unfavorable growth patterns and these may complicate treatment results.

The Dental Analysis

This part of the analysis is designed to confirm the clinical observations already made and to determine the position of the dentition with respect to their respective bony bases and to each other.

Maxillary Incisor Position

The maxillary incisor is related to the N-A plane both by angular as well as linear measurements. The upper incisor to N-A reading in degrees indicates the relative angular relationship of the upper incisor teeth, whereas the upper central incisor to N-A reading in millimeters provides information on the relative forward or backward positioning of the incisor teeth to the N-A line (Fig. 9.33F).

The upper central incisors should relate to the N-A line in such a way that the most anteriorly placed point of its crown is 4 mm (but may range up to 7 mm) in front of the N-A line and its axial inclination bears a 22° angle to the line. To precisely determine the relative anteroposterior position of the incisors, it is necessary to measure the distance of the most labial surface of the incisor to the N-A line.

Mandibular Incisor Position

The relative anteroposterior linear position and angulation of the lower incisor teeth is determined by relating the most protruding incisor tooth to the N-B line (Fig. 9.33G). The lower incisor to N-B line measurement in millimeters shows the relative forward or backward positioning of these teeth to the N-B line. The lower central incisor to N-B reading in degrees indicates the relative axial inclination of these teeth.

The most labial portion of the crown of the lower incisor teeth should be located 4 mm ahead of the N-B line, and the axial inclination of this tooth to the N-B line should be 25°.

Inter-incisal Angle

The inter-incisal angle relates the relative position of the upper incisor to that of the lower incisor (Fig. 9.33H). If the angulation is more acute or less than the mean of 130°, then the anteriors are considered to be proclined. Hence, the upper and or lower teeth may require up-righting or need to be retracted. Conversely, if the angle is greater than 130° or more obtuse, the upper and/or lower incisors may require

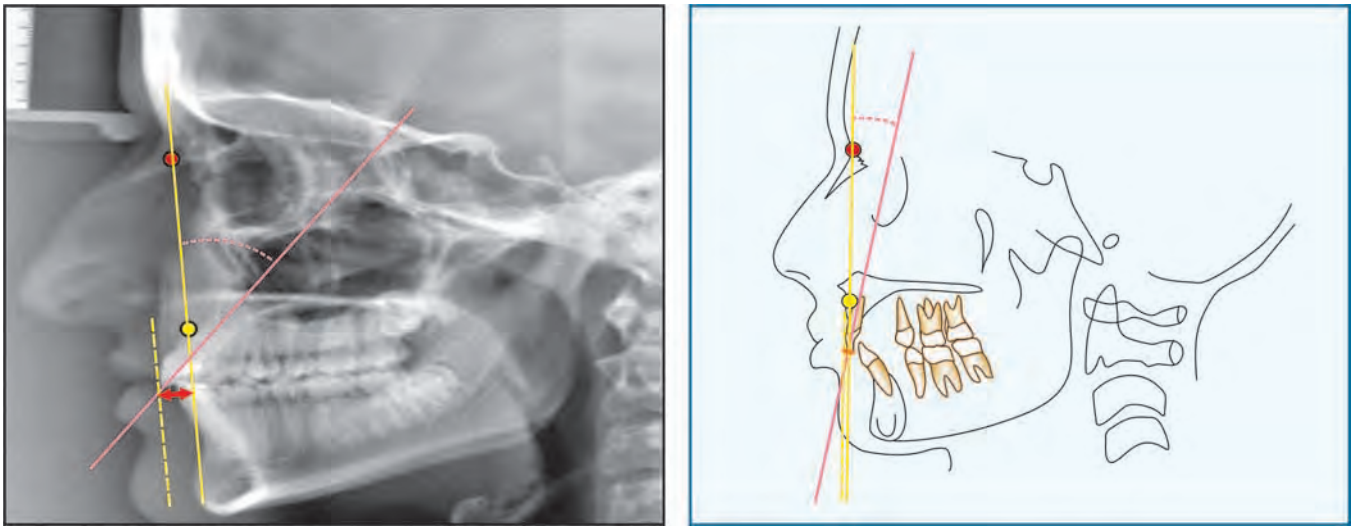


Fig. 9.33F: Maxillary incisor position—the red line denotes the linear measurement from the N-A line (yellow line) and the angular measurement between the N-A line and the long axis of the maxillary incisor (pink line)

profile. Orthodontic correction usually entails advancing the teeth in the dental arches to protrude the lips to approximate the S-line.

TWEED ANALYSIS

Tweed developed this analysis as an aid to treatment planning, anchorage preparation and determining the prognosis of orthodontic cases. At that time great emphasis was laid on the placement of the mandibular incisors for the preservation of the orthodontically achieved results.

This analysis is based primarily on the deflection of the mandible as measured by the Frankfort mandibular plane angle (FMA) and the posture of the lower incisor. The analysis is done to determine the final position, the lower incisors should occupy at the end of treatment. Once the final position of these teeth has been determined, the space requirements could be calculated and decision regarding the extractions could be made. Dr. Tweed established that prognosis could be predicted relatively accurately based on the configuration of the triangle.

DESCRIPTION

The analysis consists of the Tweed's triangle formed by (Fig.9.34):

1. Frankfort horizontal plane.
2. The mandibular plane.
3. The long axis of lower incisor.

The three angels thus formed are:

1. Frankfort-Mandibular plane (FMA)
2. Lower incisor to mandibular plane (IMPA)
3. Lower incisor to Frankfort horizontal (FMIA)

The normal values for

FMA = 25°
IMPA = 90°
FMIA = 65°
ANB = 2° with a range of 5 to -2°.

The basis is the FMA angle, and the following can be derived from the change in its value as:

1. FMA 16° to 28°: prognosis good
   at 16°, IMPA should be 90° + 5°= 95°
   at 22°, IMPA should be 90°
   at 28°, IMPA should be 90°–5° = 85°
   Approximately 60 percent malocclusions have FMA between 16° and 28°
2. FMA from 28° to 35°, prognosis fair at 28°, IMPA should be 90°–5° = 85° extractions necessary in majority of cases at 35°, IMPA should be 80 to 85°
3. FMA above 35°, Prognosis bad, extractions frequently complicate problems.

Tweed stressed the importance of the FMIA angle, recommending that it be maintained at 65 to 70°.

The Tweed analysis is primarily for clinical treatment planning and should not be considered a complete analysis by itself. By establishing the position lower incisors should occupy, provisions are made for variations in mandibular position and the upper

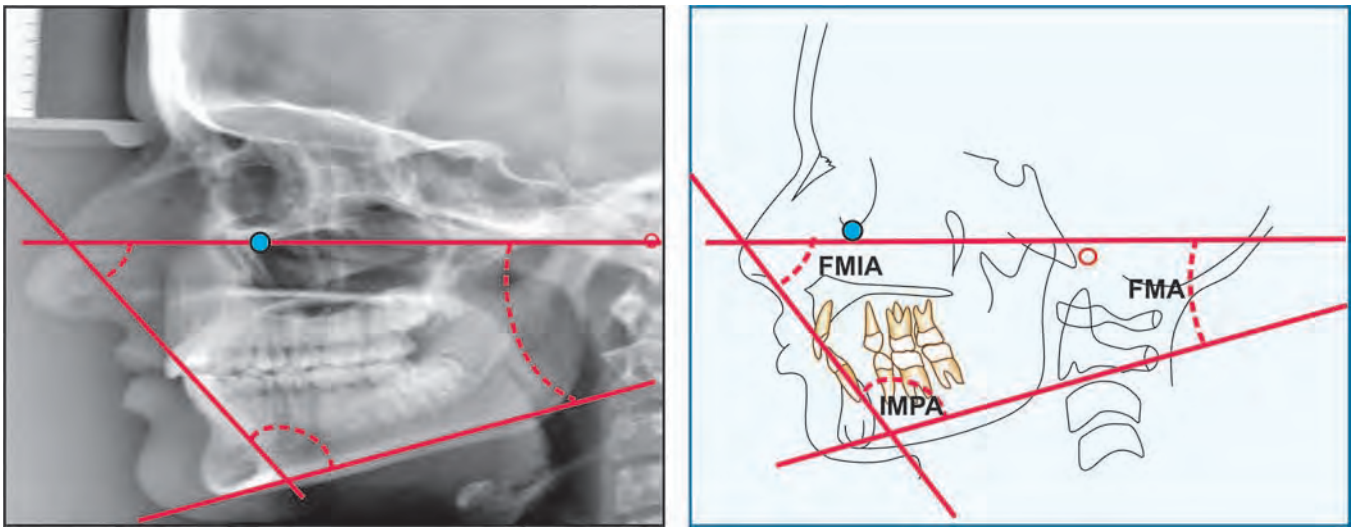


Fig. 9.34: The Tweed diagnostic facial triangle